P-2.1 Represent vector quantities (including displacement, velocity, acceleration, and force) and use vector addition.

Revised Taxonomy Levels **2.1 B Represent (interpret) conceptual knowledge**
3.2 C_A Use (implement) procedural knowledge

Key Concepts
Vector
Scalar
Vector addition
Component vector
Resultant vector

In physical science, students are introduced to the conceptual aspects of direction involved in displacement, velocity, and acceleration, and the ways that motion is affected quantitatively by forces in the same and opposite directions.

- Displacement
  - The quantities distance and displacement are differentiated and students explore the value of each in describing the motion of an object.
  - Displacement is defined as having both magnitude and direction.
  - The final displacement of an object is addressed only in the context of motion in one direction vs. motion in opposite directions. (No vector addition)
- Velocity
  - The quantities speed and velocity are differentiated and students explore the value of each in describing the motion of an object.
  - Velocity is described as having both magnitude and direction and students explore the concept that the velocity of an object can change if either the speed or the direction of the object is changed.
  - The final velocity of an object is discussed in terms of total displacement divided by total time as outlined above.
    - In terms of same or opposite-direction displacement
    - No vector quantities
- Acceleration
  - Acceleration is defined as a change in velocity, speeding up, slowing down or changing direction.
  - The rate of acceleration is determined by both the degree of change in the velocity and the time it takes for that change to occur.
  - Positive and negative acceleration are introduced in terms of speeding up or slowing down.
  - The affect of displacement on the rate of acceleration is not addressed quantitatively. (Only that a change in direction does change velocity so an object with constant speed but changing direction is accelerating).

- Forces
  - The concept of net force is addressed in terms of an applied force and an opposing force (friction). Or in terms of two applied forces in the same direction. Students identify each force from a story problem and solve for the net force. (In terms of forces applied in the same direction or in opposite directions, no vector problems).
  - The idea that the direction of a force is important in determining the effect on an object is explored conceptually.

With a basic understanding of how direction affects these quantities (displacement, velocity, acceleration, and force), physics students will use vector diagrams to represent their magnitude and direction and determine the resultant when two or more of any of these quantities are combined.

As Physics for the Technology classes and traditional college prep classes will have different curricula based on the choices that are made for standards six through ten, the scope of the core curriculum should vary as well. The emphasis of topics within the core standards will depend on subsequent topics to be addressed.

It is essential for all physics students to

- Differentiate scalar (distance, speed, and mass) and vector (displacement, velocity, acceleration, and force) quantities
- Use a vector diagram to represent the magnitude and direction of vector quantities (displacement, velocity, acceleration, and force)
- Solve problems using vector analysis

College prep differentiation

- Solve vector problems analytically (using trigonometry) to find either the resultant of two vectors, or the components of one vector

Physics for the technology differentiation

- Apply the graphical method of vector addition to linear mechanical problems (head to tail vector addition) to find either the resultant of two vectors, or the components of one vector.

Assessment

The verb interpret (represent) means that one major focus of assessment will be for students to "change from one form of representation to another", in this case, the motion of an object can be represented in three forms: verbal description, organized data, and graphical representation in the form of vector diagrams. When information about the motion of an object is given in any of the above three forms, students should be able to represent the motion of that object in the other two forms. As this indicator is classified as conceptual knowledge, it is vital that students can apply their knowledge of vector diagrams and their understanding of motion to graphically represent any novel set of data, or verbal description.

The verb implement (use), means that the other major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator is "knowledge of subject-specific techniques and methods" In this case the procedure is the application of the procedure for vector addition to find the resultant of any two vectors or the

components of a single vector. The unfamiliar task is a novel word problem or a set of data. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of each of the types of motion and an understanding of the effect that they have on one another.